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GENERAL INSTRUCTIONS

FOR THE

HYDROGRAPHIC SURVEYORS

OF

THE ADMIRALTY.

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LONDON:
PRINTED FOR THE HYDROGRAPHIC OFFICE, ADMIRALTY;
AND SOLD BY
J. D. POTTER, *Agent for the Admiralty Charts*,
31, POULTRY, AND 11, KING STREET, TOWER HILL.
1862.

3599.

Price One Shilling.

BRITISH MUSEUM

GENERAL INSTRUCTIONS
FOR THE
HYDROGRAPHIC SURVEYORS
OF THE ADMIRALTY.

GENERAL OBJECTS.—The general object of a Hydrographic Survey is to produce such a chart that every part of a sea-coast may be at once recognized by a stranger, so that he may without hesitation perceive the best manner of approaching or receding—of passing or quitting it—of maintaining a fit position in the offing—or of entering its ports without the aid of a pilot; and all, under every state of weather, wind, and tide.

CONDITIONS OF A GOOD CHART.—To produce a good chart, much more must be given than a mere outline of the shore with its general soundings and its off-lying dangers: a complete chart should at one glance convey to the eye, not only the relative position of its principal points and inflexions, but its varying *character*—whether springing abruptly from the sea in precipitous cliffs, or rising in bold acclivities, or in gentle slopes—whether broken into scattered points of rock, or throwing itself out in salient prongs and shelving ledges—whether its bays are encumbered with foul ground, or lined with a smooth open beach—and especially whether it is easily accessible, with regularly decreasing soundings, or fronted by intricate banks, and unconnected reefs, which, to pass through or to avoid, require a well-concerted series of sea-marks.

In such a chart the extent of the shoals, with the limits of the intervening channels, should be so manifest, the set of the tides so consistently expressed, and the directions so terse and simple, that by the rapid opening or closing of the marks, and the fullness and sequence of the soundings, the mariner should be able to trace the movement of his vessel in every fresh cast of the lead, and thus to feel his way with equal decision, promptitude, and confidence.

TOPOGRAPHY.—The topographic portion also of such a chart should be complete; it should contain not only all the principal features which are conspicuous from the offing, but even the secondary objects which by their relative situations may serve to lead forward the eye to those that have been selected for sea-marks. And as it is of importance that those marks should be instantly discernible, some slight description might be annexed either to them or to the objects which serve to point them out; for instance, suppose a clump of trees to be the cross-mark denoting the entrance of some winding channel—the chart should tell whether it consists of slender poplars, rigid firs, or of wide-spreading oaks;—again, if a church or temple or mosque, has it a dome or square tower or pointed spire or minaret; or again, a series of cliffs may duly appear in the chart, yet how satisfactory to have some idea of their relative heights, or to learn that certain parts of them are red or white, or mossgrown, or the strata vertical, horizontal, or inclined, &c.

In short, during the whole progress of a survey, it should be steadily borne in mind, that with whatever skill and labour it may be executed, it is only the means to an end; and that its real merit will less depend on the science and taste which have been employed in its construction than on the practical utility of its results. Maps and charts may indeed be made to convey a very wide range of information, if properly compiled and dexterously arranged—the more necessary matters being made obvious and patent, and the others kept in due and relative subordination; but what the seaman chiefly wants is a chart exhibiting at one view all that may be necessary for the immediate conduct of his vessel; and to have that graphically and perspicuously expressed without indecision or ambiguity; as, clear channels, easily seized leading marks, well defined shoals, and with the usual anchorages marked by an anchor.

FIELD BOOK.—In the conduct of an extensive survey it will be found convenient to divide it into certain branches, each of which will afterwards have to be separately discussed and digested; but the immediate and general receptacle for all information, direct as well as incidental, should be the Field Book; and on the quick perception of appropriate facts, and the assiduity with which they are collected, and entered therein, the efficiency of the survey will mainly depend. No explanatory hints should be left to memory, for long intervals of time may elapse before some of those running entries can be classed or applied; and many small but valuable circumstances, which would otherwise be forgotten, may be recorded in the field book by a single word, or preserved by the most concise sketch.

The immediate committal to paper of everything worthy of remark is a principle that cannot be too strongly upheld, and therefore even the method of making these entries is a matter of so much importance that, in the very outset of the survey, one uniform system of notation should be strictly prescribed to all the assistants, and everything should be expressed in plain language, or by intelligible symbols,* so that if any accident should befal the writer, the fruit of his observation might not be lost. If other symbols be employed than those officially published, a distinct glossary of them should accompany the survey, so that an appeal may be made to it at any future period when laid up among the records in the Admiralty. Nor let any surveyor be afraid of overloading his note-books: what may appear trivial at one station will often furnish a valuable link at another: even a few repetitions can do no harm, and may not be without their utility in the last stage of the work, when he is digesting the accumulated mass of materials, and drawing up the descriptions and Sailing Directions.

Surveys in different parts of the world, and of different kinds of coasts, may require different modes of treatment; but there are certain operations which must be involved in all surveys whatever, and which may be conveniently classed under the following heads:—

The NATURE of the SHORE, whether up-right cliff, shelving rock, sandy beach, marsh, or mud bank, should, as a matter of course, be distinctly indicated; but far more than those leading facts may be easily and usefully expressed; for instance, its general elevation and degree of slope, whether bare or bushy, broken or continuous, dry or swampy, wild, cultivated, or planted—in short, what may be called the complexion of the land. Convenient landing places also, and on an uncivilized coast, the character of the natives; the materials of the beach likewise, whether sand, gravel, shells, shingle, or stones, should be displayed according to the mode pointed out in the paper of Abbreviations accompanying the Admiralty Charts, as well as many other obvious characteristics, which need not be enumerated. Towns and buildings may be tinted red, and sandy beaches yellow.

SURF.—The comparative degree of surf at different parts of the shore, the distance at which it begins to form, and the winds by which it is chiefly excited, should be especially mentioned in the charts, and minutely described in the Directions. As connected with the subject of surf, every fact should be collected which can throw any light on the mysterious cause of the periodic Rollers that are peculiar to certain parts of the globe.

WATERING, WOODING, and COALING.—All places fit for these operations will of course be marked; and the *purity* of the water, the *kind* of wood, and the *quality* of the coal as steam coal, as well as the comparative facilities for their embarkation, should be added in the Directions.

ALLUVIAL DEPOSITS.—Where alluvial deposits have protruded the mouths of rivers, and where accumulations of shingle, sand, or mud have advanced the line of the coast, it will be satisfactory to ascertain from the inhabitants, or from former charts, its annual rate of progress; as well as to record by precise and durable cross-marks the present limit or tangent of such projection, for the sake of future comparison.

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* *See* Raper's ingenious paper on symbols, "Practice of Navigation," p. 381, 5th edition.

APPEARANCE of the LAND.—The general aspect of the country should be expressed, that is, whether barren or fertile—whether marked by any decided change in the vegetation, or by the alternation of rocky strata—as each point of interruption or change becomes an excellent landmark for the navigator. As it will be of great assistance to him to know the general appearance of the shore which he is about to approach for the first time—so therefore a good chart should show all the mountains and hills that may be *seen* from the offing, with whatever conspicuous objects stand upon their sea face. But as an erroneous picture of a country would be given by exhibiting only the peaks and highest points (as if it were dappled with isolated hills,) the ridges of inferior elevation by which they are connected should also be slightly expressed.

HEIGHTS of HILLS and CAPES.—The heights of remarkable mountains, hills, headlands, and islands should be measured, when possible, with accuracy, either trigonometrically or by the barometer, or by angular altitudes, corrected for the earth's curvature and for terrestrial refraction, or, if nothing better can be done, they should be estimated on the spot, say by three persons; always noting by which mode the height has been ascertained. Throughout the whole survey these heights should be unsparingly inserted in the drawings as a guide to the engraver; a due selection from them will afterwards be placed upon the charts as helping the seaman to identify the land, and as affording a direct and ready means of ascertaining its distance.

Every small islet and low rock which just shows its head above water should likewise have its height plainly figured on the chart, it being a great satisfaction to the anxious stranger to know whether he is to look out for an object 5 or 50 feet above the surface.

TOPOGRAPHY.—The topography of the adjacent country need seldom extend to any great distance in-shore; yet the positions of villages and populous districts, churches, temples, mosques, pagodas, forts, bungalows, large and conspicuous houses, and all remarkable and peculiar objects which can be seen from seaward should invariably be inserted; also, the roads or paths by which to communicate with the nearest inland towns, and whether there is a railroad or electric telegraph in the vicinity, or likely soon to be.

LIGHTHOUSES.—All lighthouses, whether recently erected, or long known, should be minutely described and sketched, and their positions accurately ascertained or verified. The character and brilliancy of the light, the intervals of its flashes, or of its re-appearance if revolving or intermittent; whether the illuminating apparatus be dioptric and refracting by lenses, or catoptric by reflectors, and its order or class; likewise the bearings on which the light is either visible or obscured, the height of the centre of the lantern above the high water of ordinary spring tides, or above the mean water level, the height also of the building from the base to vane, its form, colour, or other peculiarity; in short, every particular which can give the seaman the requisite information should be stated in the chart or in the Sailing Directions; and moreover, in case of a new light, or error in description of an old light, it should be immediately reported to the Admiralty, by special letter, in order that the correction may be made in the published Lists of Lighthouses.

RIVERS.—The courses or directions of the reaches of rivers should be laid down as far as the tide extends, or that the water is salt, or that they are navigable for vessels of a certain size, or as far as the first bridge; their varying breadths should be measured, and noted in yards in different places, and the comparative strength of the stream ascertained before and after rains. The average summer level should be recorded, as well as the greatest height to which they have been swollen by winter floods or melting snows. If time admits, a line of levels might be run up from the sea so as to determine the fall of the river per mile; and sections given at certain intervals of the form of the bottom, by which, with the corresponding velocities of the stream, the whole volume of water poured out can be computed. The prudent officer will perceive that none of these injunctions will apply to rivers which may be supposed to engender endemic disease, or where hostility with the natives might be the consequence of too prolonged examination.

SOUNDINGS.—Next in importance to the accuracy of the coast-line is the precision and fullness of the soundings, to which the quality of the bottom should be invariably annexed; for in approaching the land in foggy weather, the nature of the ground is often as much a guide as the depth of water, sometimes more so. In nearing the English Channel on the usual and best parallel of 49° 20′ N. the same depth of 73 fathoms occurs at spots 125 miles apart; but in the case of the outer depth the bottom is "fine sand," at the inner it is "oaze," which distinction, in foggy weather, is therefore the mariner's only guide. The nature of the ground will be found to show itself better if the arming of the lead be preserved until it is dry. The importance of sounding is not sufficiently considered by young surveyors; the officer in charge is often deterred from advancing young assistants to take a share in the triangulation of a country from knowing that they would consider it beneath their dignity to be sent to sound when they have once been trusted with a theodolite.

QUALITY of the BOTTOM.—There can be little doubt that the substances which are spread over the bottom of the sea are, as a general rule, derived from the abrasion of the adjacent shores, and in some places they have as evidently been swept there by currents from a considerable distance, so that it would be most desirable to endeavour to trace them to their respective sources. As, for instance, if scoriæ or volcanic ashes are found in deep water in the middle of the Atlantic or Indian or Pacific Ocean, or in the Eastern Seas (as doubtless they would be if carefully searched for), where is the nearest volcano whence they have probably come? or are there grounds for suspecting submarine volcanic agencies near the spot? These are no longer inquiries of only scientific interest, but now that the submarine electric telegraph cables are laid in so many directions, they have become questions of great practical importance, which the surveyor is bound to investigate.

So varied and ambiguous are the terms applied by seamen to the materials brought up by the lead, that, in special cases, and deep sea soundings, specimens of each kind should be preserved and transmitted to the Admiralty; and as difficulty will arise from the melting of the tallow in warm climates, each arming may be plunged into hot water, which will float off the grease, and leave the residue to be neatly folded up in paper, or better, put into strong wide-mouthed small square glass bottles, which should be at once labelled and registered. If there is reason to suspect there may be minute living animals, the bottles should contain equal parts of proof spirits of wine and water to preserve their bodies from decay.

FULLNESS of SOUNDINGS.—In a published chart, soundings should not be overcrowded, for there everything should be so distinctly arranged as to meet at once the sailor's hurried eye, but on an original plan they can never be too numerous—they should show the very form of the bottom, and the length and breadth of all its undulations. In harbour, river, or engineering plans on a large scale, the soundings should invariably be run in close sections at right angles to the course of the stream, every sudden irregularity of depth should be traced through all its lines of approach, and each insulated knoll or ridge should be *rayed* off. In shallow water, a more certain implement than the lead-line will be a long pole, graduated to feet and inches, with a flattened weight at bottom to prevent its sinking into the mud.

In nothing will the skill and dexterity of the surveyor be more advantageously displayed than in seizing at once upon judicious marks on the shore for the lines of direction that his boat is to pursue, and then in selecting two other objects, or one object nearly at right angles to his course, the rapidly changing angle of which intersects broadly the line of direction, and thus determines, with precision, the position of each cast of the lead, if necessary. Where a narrow channel or bar is to be minutely sounded, or a harbour to be thoroughly surveyed, chance will scarcely furnish a sufficient number of marks at proper intervals and pointing in right directions ; and in such cases he must have recourse to a series of small flags, or other objects, previously fixed and numbered.

SOUNDINGS to be REDUCED to LOW-WATER.—All soundings, in all charts, should be expressed by one uniform system, and should represent the depths reduced to the low-water level of ordinary spring tides ; but as the requisite corrections for their gradual changes during the operation, can only be applied by the subsequent comparison of the work in the boats with the simultaneous tide column shown on the tide gauge, the place of that gauge, and the fidelity of its records, will be points of prime importance ; the setting up the tide gauge and beginning a series of observations should therefore be the first step in every survey. The watches used in these operations should be good pocket watches, made to agree every morning, and compared every evening. The lead lines should be daily measured after being first well wetted. The assumed low-water level should be always referred to some permanent *datum* on the shore, which hereafter can be easily recognized, say the *mean-tide* level of the sea, as that is a standard which may be always recovered by observation. The limits to which equinoctial and extraordinary ranges of the tide have been known to reach should always be noted, in order that the stranger may not trust too implicitly to the depths marked in the chart on the bars and shoals, as reduced to the low-water level of the ordinary springs.

CONTOUR LINES.—It contributes much to the plainness of a chart, and therefore to the confidence with which seamen would use it, especially when entering a strange port, to have the limits or contouring lines of certain convenient depths traced with dots, indicating the number of fathoms, between 1 and 5, according to the nature of the port and the class of vessels likely to frequent it ; and it will render the channels clearer if the 1, 2, and 3-fathoms lines be lightly shaded ; the 10, 20, and 100 fathoms edges along the coasts should also be dotted.

In shallow harbours, say under 5 fathoms depth, the soundings should be expressed in the chart in feet ; and it is always to be prominently stated on the drawing, whether the depths are given in feet or fathoms. In tidal pier harbours, the contour lines for each 2 or 3 feet rise of tide should be drawn over the dry banks up to high-water mark.

DEEP SOUNDINGS.—The off-shore soundings should be always carried into deep water, and when possible to the 100 fathoms edge of the bank. When the boats are away with the surveying parties, if the ship be not at anchor, she should invariably keep the deep-sea lead going at regular intervals of time, or of distance, whatever little expectation there may be of reaching the bottom : and in approaching the land, as well as in the several runs which the vessel may have to make in the course of a survey at a distance from the shore, no opportunity should be missed of throwing down the deep-sea lead. The negative knowledge, conveyed by *no bottom* soundings in the charts, is next in value to that of the actual depths ; and, when on her ground, it should be the established practice of a surveying vessel, though apparently remote from any bank, to have a deep cast of the lead every 10, 20, or 30 miles, according to the distance from the shore. This might sometimes lead to useful discoveries ; and it is greatly to be wished that during calms, and when not otherwise inconvenient, it were a general rule in all H.M. ships to get a cast of the deep-sea lead to the full extent of the line.

In order to abridge the labour of frequently hauling in a long scope of line, every surveying vessel should be provided with a well constructed sounding-winch, which by a strap might be readily connected with and worked by the engine when the steam is up. In proper situations the free use of Massey's sounding machine will both save time and promote accuracy, and it may be used to a considerable depth, but it should be often carefully verified by a series of comparisons with a carefully measured line when the ship is still and the water smooth.

DEPTH of the OCEAN.—When the stores of the ship will admit of it, convenient opportunities should be taken of a calm and smooth sea, to ascertain, if possible, the depth of the ocean, at great distances from land. This may be done by means of a pig of ballast, or other heavy weight, attached to a long line of rope or spun yarn, marked at every 100 fathoms, and so carefully reeled up as to give no check when running off with the utmost velocity. A great deal of the line will necessarily be lost in the process, but the knowledge gained by such experiments will be of greater value. An instructive account, by Captain Sir James Ross, R.N., of a successful operation of this kind in the South Atlantic in March 1840, in which he struck the bottom in 2,677 fathoms, will be found in the Nautical Magazine for July 1840. To prevent the ship from driving over the line and pressing against it, he dropped the weight from a boat at a little distance, but retained the reel on board ; and he gives the times taken by each hundred fathoms of descent, the whole of which occupied 53 m. 8 sec. The line used was three-yarn spun yarn, laid up on board, and the weight 540 lbs. of iron.

Another useful paper on the same subject, by Captain Barnett, R.N., was published in the Nautical Magazine for March 1849; but the latest accounts of deep-sea sounding, (which process within the last few years has become almost a common occurrence,) are by Commander Maury of the U. S. navy, in his Sailing Directions and Physical Geography of the Sea ; by Lieutenants Brooke and Lee of the U. S. navy, in the cruise of the *Dolphin* in 1855 ; by Captain Spratt and Commander Mansell, R.N., in the Mediterranean sea in 1857 ; but especially in the account by Commander Dayman, in H.M.S. *Cyclops*, of a line of deep-sea soundings carried across the Atlantic from Ireland to Newfoundland, in July 1857, during which the greatest depth reached was 2,400 fathoms; and in a more recent line of soundings run by Captain Sir Leopold McClintock, in H.M.S. *Bulldog*, from Scotland to Iceland, Greenland, and Labrador and return across the Atlantic in August 1860. During this voyage a similar depth of 2,400 fathoms was reached and a specimen of the bottom brought up.

It is now generally recognized that, unless the ship be specially fitted for the purpose, it is better to sound with twine, mackerel line, cod line,* rope yarn, or spun yarn, carrying as heavy an iron weight as it will bear, (seldom less than 1 cwt.,) and to haul the line up taut until it breaks, but not to expect to recover the weight. If the line is fairly smooth, the weight will probably run down 2,400 fathoms in from 50 to 60 minutes; the sounding may be made from a boat anchored by a heavy pig of ballast at a depth, of 50 or 100 fathoms (or from the ship if she can be kept over the weight,) and the intervals of each 100 fathoms of the line running out should be carefully noted. As, when every preparation is made, a deep-sea sounding may be obtained in this manner in about one hour† on a calm day, and at a trifling expense, it may be hoped that the intelligent officer will avail himself of every favourable opportunity to aid in solving that highly interesting problem in physical geography, the Depth of the Ocean.

All specimens of the bottom brought up from great depths in any ocean (if free from grease or other compound) are highly valuable, and should be preserved as already mentioned, in strong wide-mouthed small square glass bottles labelled and registered. And it should not be forgotten that when accompanied by careful notes of the time of descent of equal parts of the line, they afford together the most direct, and in fact the only *conclusive* testimony to the success of each experiment.

TIDES.—A minute examination of the Tides, including all the data by which the Tide Hour or *Establishment* for each port may be accurately computed, as well as their local set, and the extent to which they are influenced by periodic winds and by sea currents, is so prominent a part of every survey that it need scarcely be dwelt upon here.

And as the subject of the tides has been discussed in such a large and masterly manner by Sir John Lubbock and Dr. Whewell, in the *Phil. Trans.* of the Royal Society, as well as by Mr. Airy, the Astronomer Royal, in an article on Tides and Waves in the *Encyc. Metrop.*, so it should be the willing duty of all officers who have it in their power to contribute fresh facts for their investigation. In this respect, as well indeed as for the more certainly obtaining the true Establishment, and also for determining the diurnal inequality of the tides, the time (mean-time at place) and height of both high and low water should be as carefully registered, at night, as are the observations made by day for the purpose of reducing the boat's soundings; and in all those places which are affected by interposing tides, or whenever there is reason to apprehend any anomalies in the laws by which they are governed, the observations should be made with increased diligence and accuracy. In all cases, in order to obtain the instants of highest and lowest water, it will be necessary to register the observations at successive intervals of five or ten minutes both before and after the culminating points, and then to adopt the mean of the middle times shown by each corresponding pair of heights.

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* Messrs. Newall, of Gateshead, by means of their vertical rope-making machine spin this line in any length that may be required without joining. Reels of it, of 1000 fathoms in length, are found most convenient for use. A length of 100 fathoms weighs in air about 5½ lbs.

† Not, of course, if the bottom is to be brought up, which must be by a separate operation, and will probably occupy three hours. In this case the *Bulldog*, or some other detaching apparatus with a good scoop or clam, should be used.

If so circumstanced that a continuous series of observations cannot be made, the times and heights of high and low water should be taken when the moon passes the meridian of the place between 11^h and 2^h, and also between 6^h and 8^h, of which there should not be less than five observations of each. The error of the watch on mean time at place should always be given. To carry out these views with certainty and consistency it will be desirable that this department of the survey should be assigned to two or three steady persons, perhaps quarter-masters, who should each sign the register, and who should be taught to feel a pride in the correctness and completeness of their observations. As printed forms, named Registers of Tides, are supplied to all surveying vessels, these forms duly filled up are to be transmitted to the Admiralty without delay, in order that the reduction of the observations may be at once proceeded with.

TIDE STREAMS.—Beside the obvious conclusions which will have to be inferred from these registers, such as the periods of high, and mean, and low water, the progress of the tide-wave (as distinguished from the tide-stream,) the comparative height of the day and night tides, and the effect of freshes on both the heights and times, it will be necessary to determine the varying direction and force of both the flood and ebb streams, in different parts of the port or river and at its entrance. In marking on his chart tide-streams in the offing the Surveyor should be careful not to confuse himself by the words "flood" and "ebb stream," but rather to use the terms "east" or "west" going stream, as the case may be. In the English Channel, for example, the eastern stream runs up at times 3 and 4 hours after high water by the shore abreast, and the water is falling, or it is ebb tide in those harbours, while the eastern, or flood stream, as it is called, is still running up. In the same manner in the North Sea, the north-east going stream (or ebb as it is called) makes to the eastward 2 hours before it is high water at Dunkerque, Ostend, &c.

TIDE WAVE.—Finally, the progress of the tidal wave or undulation (marked by the successive times of high water) must be traced along the coast from port to port, and through the modifications which result from projecting promontories, deep bays, or lateral channels, or meeting tides, all of which influence it. The Surveyor must be on his guard against confounding the tide stream and tide wave; the former runs up, along the east coast of England for example, at about 2 miles an hour, but the tide wave or undulation moves at the rate of nearly 60 miles an hour along a straight coast; but much more slowly up a river encumbered with shoals; thus from Tyne Bar to Filey Brigg, a distance of about 60 miles of open coast, the tide wave takes only 60 minutes, whereas it takes the same time from Tyne Bar to Newcastle Bridge, a distance of only 10 miles. If, however, a river be free from shoals and obstructions, the tide wave moves up it about half as fast as along the open coast, as in the Thames from the Nore to London Bridge, a distance of 41 miles, the tide wave takes only 97 minutes; from Harwich to Ipswich, 9 miles, only 30 minutes. The progress of the tide wave may, therefore, be taken as an approximate test of the state of a river and its freedom from obstruction.*

In order to have a distinct view of all the tidal phenomena, the register should have additional columns for the direction and force of the wind, and for the fluctuations of the height of the barometer (at the level of the sea), which should be noted at each high and low water; a careful analysis of which would in a few years determine the ratio in which the surface-level of the sea is affected by the pressure of the atmosphere.

The daily tides for 24 ports of the United Kingdom with Constants for about 200 other places are now carefully computed in the Hydrographic Office, and annually published for the benefit of the mariner; the Time and Height of high water at Full and Change for upwards of 2,300 of the principal places on the globe are also given; but additional series of *correct* observations are greatly wanted in order to extend these latter Tables, and to render them more accurate.

CURRENTS.—Many efforts have been made to ascertain, and to record for the use of navigators, the prevalent currents of the ocean, but hitherto with no very great success; for, besides their own apparent inconstancy, the observations on which our current-charts have been constructed were, till within these few years, vitiated by the neglect of the deviation of the compass. In general also the daily error of the reckoning at each following noon has been adopted as the effect of a single current acting throughout the whole interval; whereas it is probable that in every twenty-four hours the ship will have passed through different streams, and have been affected by different impulses. He, therefore, that is desirous of forming consistent views on a subject so necessary in every voyage, and so deeply interesting when considered on a more extensive scale, will contrive that systematic observations for latitude and time by the sun, moon, stars, or planets should be made at different hours of the day and night, taking advantage of the clear horizon an hour before sunrise and after sunset, for the express purpose of apportioning the whole error of the day's work into its most likely periods. Then and then only after a due consideration of the probable effects of bad steerage in the different watches, of the action of the swell and sea upon the lee-way, and of the gradual but constant changes in the variation and deviation, will his arrow on the current chart be considered of any authority.

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* See the "Directions for Tide Observations," in the Admiralty Manual, by Dr. Whewell; and two papers by Captain Beechey in the Philosophical Transactions of 1848 and 1851, (reprinted annually in the Admiralty Tide Tables supplied to all H.M. ships,) "On the progress of the Tidal wave up the English and Irish Channels."

Such is the practice in every skilfully conducted voyage, and as it would therefore appear to be a duty peculiarly incumbent on all surveying vessels when going out or returning from distant stations, it may be as well to divide the inquiry into distinct heads :—

1. What is the local set and strength of the current for any specific interval, as shown by a carefully corrected reckoning when disentangled from all probable errors ?
2. Over what extent of space, and at what seasons, does the current appear to have a certain degree of permanence and regularity ; and how far is it modified by the daily sea and land breeze, or by the periodic monsoons, or by the varying issue of large rivers in those changes of season ?
3. In the vicinity of such rivers does any undertow exist ? This may be readily discovered by sinking a basket attached to a little float, and tried at different depths.
4. To what distance does the usual current extend from the coast ; and where does any neutral space or counter current begin ?
5. Is the general direction of the permanent current parallel to the shore, as in the bight of Guinea ; or oblique to it, as along the coast of South America ?
6. To what depth do these currents extend downwards ?

SUBMARINE CURRENTS.—And this will open to the inquiring seaman the still larger question of the deep submarine currents, which it is asserted have been found of considerable strength—even 1¾ knots, at 120 fathoms below the surface. It is indeed difficult at first sight to conceive the causes that can give a horizontal impulse to a large zone or stratum of water, at any material depth, so as to preserve it distinct from the water above and beneath, and to continue to it for any length of time an independent movement ; but it is not the less our duty to contribute our utmost to the supply of honest and genuine observations, which can alone confirm or refute that supposition.*

Experiments for this purpose will cost but little trouble in comparison with the satisfaction they will afford to the navigator, or to the light they will throw on some of the great operations of nature, but then they must be conducted in such a manner as to prevent all uncertainty and incredulity. Whenever attempted, three, if not four, large current logs should be sent down at the same time, and so buoyed as to be kept at different depths—say at 10, 20, 50, 100 fathoms or more,—besides one which in all cases should be kept riding on the surface; and it will be still more satisfactory if two such experiments be carried on at the same time, and at the distance of a few miles apart; for if such deep currents should thus be proved really to exist, it is possible that they may be produced by a kind of whirl or vortex of large diameter in the superficial current.

The comparative temperatures of the atmosphere and the sea should be continually observed and marked in the log, with reference to the current, for they will often show that it runs from the northward to the southward. On one occasion a ship crossing from the Cape of Good Hope to the Rio de la Plata, was enabled to foretel the daily error in her latitude, by the increased warmth of the water if the current was coming from the northward, or by its comparative coolness if a stream was setting up from Cape Horn. Repeated series of such observations will show under what circumstances the thermometer may be expected to indicate the presence of a current.

The trend and general figure of fields and patches of seaweed should also be noted with the same view, as both must be more or less affected by the direction and velocity of the current. Where the patches are frequent or of considerable extent, a deep cast of the lead (say 1,000 fathoms), should be obtained, as they may possibly indicate the proximity of banks.

WAVES.—Among the other useful observations which might engage the ingenuity of a surveying officer, on his passage out or home, may be mentioned the magnitude of the waves in those parts of the ocean where the sea has an unlimited fetch; there being reason to believe that the altitude to which they are lifted, as well as the distance between two following ridges, have been very much under estimated. A good attempt may be made to measure their vertical height by mounting the rigging until a line from the observer's eye to the horizon becomes a tangent to the summit of the intervening wave—the vessel being for that moment upright, and in the lowest part of the trough between two waves.

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*See Maury on the Physical Geography of the Sea and its Meteorology. London, 1861, 10th Edition, chap. viii. § 403.

Consort vessels, being nearly in each others wake, and knowing their actual distance apart, by the elevation of each others masts, can accurately determine the breadth of the valley that separates two of these huge undulating masses. The same result may be obtained by towing an object astern at a measured distance.

VIGIAS.—The constant endeavour to pass over the places of all the Vigias which are marked near her track in the charts, should be considered as one of the prominent duties of a surveying vessel. Multitudes of those imaginary dangers are circumstantially described by Horsburgh as well as in the Nautical Magazine and other books, and are traditionally inserted in all our ocean charts, and from which they ought not to be expunged without the most satisfactory evidence of their non-existence, within wide limits of their alleged positions. It is true that pieces of wreck, sleeping whales, shoals of fish, and sundry other floating substances, may account for a large proportion of these pretended rocks ; yet, on the other hand, the mighty operations which are perpetually and silently going on in nature's great laboratory, and which are occasionally manifested by the protrusion of a real rock above water—and again by its withdrawal—should teach us not to be too sceptical as to the former existence or future confirmation of some of them.

A full day will, therefore, be well employed in every such search ; and, as it is incredible that in very deep water any rock should rise like a column perpendicularly from the bottom, the search must be accompanied by some deep-sea casts, say to 1000 fathoms at least, in order to strike some part of the slope.

With the like object in view, the observant seaman will keep his eyes open to every unusual appearance in the sea—such as partial ripplings and, when out of the reach of rivers, to all discoloured water, whether white, brown, or green, flocks of birds, or shoals of fish, as they may possibly be indication of some change in the nature or depth of the bottom ; and in all such cases a deep-sea cast of the lead should be obtained.

CORAL FORMATIONS.—It has been suggested by some geologists that the coral insect, instead of raising its superstructure directly from the bottom of the sea, works only on the summits of submarine mountains which had been projected upwards by volcanic action ; thus accounting for the basin-like form so generally observed in coral islands, by supposing that they rest on the circular lips of extinct craters. Others imagine that the submerged islands which support the coral banks are gradually subsiding, and that these zoophytes, which, they assert, can work only near the surface of the water, are perpetually engaged in keeping up their work to that level. If the latter be the case, some relative change of level might perhaps be detected by careful observations between two neighbouring islands ; but these hypotheses are only mentioned here as hints to a surveyor employed among islands and bays of coral formation, to collect all facts that can lead to any further development of these mysterious processes of nature.

In coral waters not one danger out of fifty is hidden; in general all corals or polyps only cease their labours on arriving at the surface; the reefs they form are therefore visible dangers; and as each mass rises almost perpendicularly from its nucleus, whether the waters in the vicinity are either unfathomable, or have a moderate depth in which a vessel can anchor, the deep-sea lead will seldom indicate the approach to them.

MEASUREMENT of a BASE.—Maritime surveys being necessarily confined to narrow slips of coast, little reliance can be placed on any extensive determination of distance though resulting from the most careful triangulation, as the original errors of a short and assumed base are multiplied by every additional triangle; and to measure a base of sufficient length with adequate precision requires time and means generally far beyond the disposal of any naval surveyor. When the general direction of the survey lies nearly in the line of the meridian, the distances may be effectually corrected by accurate latitudes; but if it lie east and west, the surveyor can depend alone for that essential object on the difference of longitude shown by his chronometers, of which he should be furnished with a large number, and he should, if possible, measure the meridian distances backwards and forwards several times. Occasionally, to determine short distances, the progress of sound has been employed, as by Captain Vidal on the coast of Africa, and Captain Kellett on the west coast of America; but this mode requires very great care, and is not recommended. (See *Naut. Mag.* for 1841 and 1852.)

On the coasts of the United Kingdom, where a trigonometrical survey has been carried over the country, in India, and in some of our colonies, as at the Cape of Good Hope, and a portion of Australia where a partial trigonometrical survey has been effected, an accurate base can be obtained from the land survey; but on foreign coasts and for the shores of the greater part of our colonies, the surveyor must trust to his own resources, when accurate observations for latitude and carefully measured meridian distances by chronometers will be his main dependence. In small bays, harbours, and rivers, a base line may occasionally be measured by a chain with advantage, but it will require great care, and should be measured twice at least, and the chain tested each time. At times, the angle subtended by a ship's mast, measured by a Rochon micrometer, may be used; and a set of Tables of mast-head angles has been published, which will be found useful for this purpose; but the accuracy of the micrometer must occasionally be carefully tested.

It is, however, possible that in some of our colonies, as New Brunswick, Nova Scotia, and Australia, the surveyor may be able to measure his own base, and carry on a triangulation; in such case the greatest care should be taken in selecting level ground, for the exact measurement of a good base, from which to start the triangulation; and as errors accumulate rapidly when the triangles are ill conditioned, the main triangles should seldom have an angle less than 25°, and new bases should be measured every ten or fifteen miles to correct any errors that may have crept in. It is also essential to the correctness of a survey, that careful observations for morning and evening azimuths be taken with the standard compass (not the theodolite) at the principal stations, so that having the true bearing of the calculated lines of the triangulation, and correcting for the convergence of the meridians, the surveyor may compare the difference of latitude thus arrived at, with the difference of latitude obtained by observations of the sun or stars. But if the direction of the coast surveyed lie nearly east and west, the correction of the scale of the work, as already stated, will be best effected by chronometric measurements for difference of longitude; and to make these with the requisite accuracy, the time should invariably be obtained by equal altitudes, and the meridian distances measured backwards and forwards several times.

CHRONOMETERS.—The value of chronometers for measuring an accurate base will impress on the surveyor the absolute necessity of his paying such unremitting attention to those delicate but most important instruments as may tend to their correctness—he will place them where they will not be affected by jolts and jars on the neighbouring decks, or by transient changes of temperature—he will bed them on cushions of springy bunting or horse-hair but not on sawdust—he will take care that nothing surrounds them which can collect damp, and generally will be careful to keep them sufficiently ventilated, perfectly dry, and free from dust—he will handle them with caution—he will wind them regularly every day—and, immediately referring all observations to them by means of a hack chronometer, he will endeavour to leave them undisturbed.

The daily comparisons should always be made by the same person, and with the greatest care; and he that would make himself really acquainted with what may be called the individual humours of each chronometer, will compare them twice in the twenty-four hours. It should be an invariable rule to enter the difference in the journal immediately, so that any accidental mistake in the comparisons may at once betray itself.

Among the many causes of irregularity in the rates of chronometers, it has been considered that one may arise from changing the position of the steel balance with respect to the resultant of the various magnetic forces of the vessel, and thus affecting the arcs of vibration; it will be prudent, therefore, to give at once to all the chronometers one invariable position; suppose with the XII. towards the ship's head. But the chief cause of irregularity is, most probably, change of temperature.*

CHRONOMETER JOURNAL.—According to the Admiralty instructions, from the day the chronometers are received on board till they are returned to the Royal Observatory, a complete tabulated journal is required from the captain, showing their daily comparisons, registering the temperature, and mentioning every circumstance by which they may have been influenced; but, in addition to that, it will be necessary for a surveying officer to record the data from which the mean rate has been inferred, and the reasoning through which he has been occasionally induced to change it; he should insert frequent remarks on the degree to which they have been apparently affected by changes in the temperature or in the motion of the ship; and he should give copies of the tables which he has computed for intermediate corrections between any two stations; in short, everything should be candidly told that can bear upon the results to which he has arrived, or that will enable him or others to revise those results in case of any future doubts or discussions.

RATING CHRONOMETERS.—By Equal Altitudes the rates of the chronometers will in general have to be determined, and those observations will well answer that purpose if made with the artificial horizon on shore, the A.M. and P.M. observations taken in the same place by the same eye, with the same sextant, and with the index unmoved during the interval; or Troughton's reflecting circle on a stand may be used if preferred.

The Transit Instrument would indeed furnish better means of fixing the rates, if the vessel should be detained long enough in any port to make it worth while to set up its tent and to adjust it with nicety; but so much accuracy and care are required in the adjustments and observations, that unless in a fixed observatory, the surveyor will probably find his own more familiar instruments, the sextant and artificial horizon, preferable and more to be depended on. If, however, the surveyor should be lodging on shore, he may contrive a substitute for the Transit Instrument by inserting three fine wires, or filaments of silk, in the eye-piece of a common two-feet telescope—screwing it firmly by a clamp to the reveal of the window (with a southern aspect if in north latitude, or *vice versâ*), and so as to be directed to any bright equatorial star on, or within a few degrees of, the meridian. The conversion of the sidereal differences into mean time will give but little trouble; and when the daily change of right ascension renders the observation of that star inconvenient, the clamp is of course to be loosened and the telescope fixed upon some other star.

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* See Captain Shadwell, R.N., on chronometers. London, 1861. Every means should be taken to preserve an equable temperature in the chronometer room. A maximum and minimum thermometer should always be kept there and registered daily.

LONGITUDE.—In most cases the longitudes of the several stations will be relatively deduced by chronometric means from the last well-determined point or standard position that was visited, but as the very best of these instruments are in some degree subject to error, and as all might possibly be more or less affected in the same sense by some one general cause, the zealous surveyor will occasionally avail himself of the various phenomena given in the Nautical Almanac for the purpose of verifying the differences of longitude which he has brought forward, and of establishing a new standard meridian for the field in which he is engaged. Eclipses of the sun and moon are rare, but moon-culminating stars and occultations are of almost daily occurrence, and, if he is provided with a tolerably good transit telescope, the former should be perseveringly observed, as they are now very generally registered in all the fixed observatories for the purpose of comparison. Occultations, however, should not be neglected; for though they are somewhat laborious to compute, yet if they take place near the equatorial region of the moon they become invaluable, and though the more active duties of the expedition may prevent their immediate reduction, they should be carefully observed and circumstantially recorded.

Neither should the eclipses of Jupiter's satellites be neglected, for though their worth entirely depends on the power of the telescope, yet they give instant results; and if (in like states of the atmosphere) the same power be employed, and by the same person, on repeated immersions, a very useful series of meridian distances will be obtained, with great precision, and with little trouble. It sometimes happens that both the immersion and the emersion of the fourth satellite may be observed on the same night, and consequently under all the above favourable conditions; in which case, the interval being so short that little change can have taken place in the rate of the chronometer, the mean result cannot be far from the truth. But the value of all these observations will be doubled if corresponding ones should have been made at any fixed observatory.

It may not be out of place to remark here that all comparative observations should be made by the same person, no two persons' eyes or ears agreeing exactly in their estimates of either space or time; and so in all delicate observations the observer should be aware of this source of error, which is called his *personal equation*, and endeavour to correct it. If in meridian altitudes of the sun, for instance, he should suspect that the habit of his eye is to make the contact of the limbs, in the artificial horizon, too close or too open, he can effectually neutralise the error by observing the other limb on the following day; but he may do much to lessen it, or at least to ascertain its amount, by repeated observations on alternate days of the upper and lower limbs.

MAGNETIC OBSERVATIONS.—These have for their object the determination of the amount and direction of the earth's magnetic force, the elements of which are known as the Variation, Dip, and Intensity. The progress of late years in magnetic science calls forth at the present time the necessity of employing the most refined instruments and delicate observations to meet the requirements of philosophers; hence it appears expedient before undertaking these observations that a course of instruction should be undergone by those selected for the service, to do full justice to this branch of science.*

There are, however, observations that can be made with ordinary instruments by every surveyor, which are of importance to seamen ; these are especially the variation, and, in a lesser degree, the dip of the needle. Both these are elements of continuous and marked change, the former now on our own shores especially, where, after a slow and gradual progression to a maximum deviation from the true meridian (not differing more than one degree from a mean value in nearly half a century), it is at the present time decreasing from six to eight minutes annually, and may probably hereafter far exceed that amount.

In the absence of a Declinometer, the Admiralty or Standard Compass affords excellent results for the magnetic variation, while experience has shown that those obtained by the magnetic needle of the Theodolite (a common mode of determining the variation) are not unfrequently liable to error from a variety of causes; a comparison of these needles with the Standard Compass should therefore be made at an early stage of the survey. In recording the observations for variation, the instrument, and the date and hour, should be appended to each, in order that by subsequent determinations the value of the periodical changes may be ascertained.

Especial care should be bestowed on the selection of a place for making magnetic observations. Granitic and trap rocks have in general a marked influence on the needle; buried anchors, gas pipes, and other hidden masses of iron, or contiguity to houses and their concealed iron work, iron rails covered with brass, and even small portions of metal about the person, as a steel watch guard, have not unfrequently vitiated or rendered useless the earnest labours of some of our best observers.

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* In furtherance of this object, Instructions for the use of Portable Instruments adapted for Magnetic Surveys, &c., by Lieutenant Riddell, R.A., were printed by the Admiralty in 1844, and a supplement in 1846.

Should the magnetic element, as determined at any station on shore, differ from the estimated value, opportunities of observing around the neighbourhood should not be neglected, in order to detect and eliminate any local influence which may exist, keeping in view that the values, as they are presumed to exist in the adjacent waters, are what are required by the mariner.

MAGNETIC OBSERVATIONS AFLOAT.—Azimuths and amplitudes should be frequently obtained, whether at sea or in port, remembering that as observations made afloat are of little or no value unless corrected for the effects due to the iron of the ship, the direction of the ship's head must be invariably noted. The "Practical Rules" published by the Admiralty* give full information on the subject of local deviation, and the article on Terrestrial Magnetism, in the Admiralty Manual of Scientific Enquiry, may be consulted with advantage.

As the lines of equal variation are now traced over the globe, it is believed with a close approximation to the truth, and as the worth of information collected in this manner is becoming more apparent to seamen, not only for the ordinary purposes of navigation, but also to determine by comparison the varying error of their compasses, pains should be bestowed in multiplying observations at sea for the variation of the compass, more especially when the track of the vessel passes through those spaces where the values change rapidly in small intervals.

All observations, whether for ascertaining the local deviation of the vessel, or for determining the magnetic elements on shore or afloat, should be transmitted *uncorrected* and in full detail to the Compass Department of the Admiralty at the earliest opportunity.

Finally, it may be observed, that as no subject can be of greater importance to the navigator than the laws which affect his compass, so none should be pursued with more perseverance.

METEOROLOGY.—The Introduction to the Meteorological Register or Abstract Log, and the Admiralty Manual of Scientific Enquiry, now supplied to all Her Majesty's ships and to many merchant vessels, enter so fully into the subject of Meteorology, and the best mode and times of making observations, that it is unnecessary to say more than that all surveyors should strictly comply with the Directions therein given.

But as these Instructions may chance to fall into the hands of those who may not have a copy of those works, it may be observed that an exact register should be kept of the heights of the barometer at its two maxima, about 9 a.m. and p.m., and at its two minima about 3 o'clock ; also of the thermometer at the above periods, as well as at its own day and night maximum and minimum, with a view of providing authentic data from various parts of the world, for the use of meteorologists.

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* See latest edition, May 1862, with special examples of iron ships, showing that each degree of heel of the ship may cause 1°, 2°, and occasionally 3° increase or decrease of local deviation.

There are likewise some occasions on which more extended observations in this department cannot fail of being useful:—

1. During the approach of the monsoon and other periodic changes of wind and weather, and then the hygrometer also should find a place in the journal.

2. The comparative temperatures of the atmosphere and the sea when passing the equator, or nearly under a vertical sun, and far away from the influence of the land. In this case the thermometer should be sent down to certain constant depths, suppose to 50 and 10 fathoms, as well as at the surface, and all these at certain regular hours of the day and night.

3. Good observations, if unremittingly continued, will be of use in connecting the isothermal or equal temperature lines of the ocean; they should be made both at the surface of the sea, and at some one certain depth, say 50 fathoms.

4. Interesting facts may result from the comparison of the direct heat of the solar rays, as well in high as in low latitudes. The two thermometers for this purpose should be precisely similar in every respect, the ball of the one should be covered with white and the other with black kerseymere; they should be suspended out of the reach of any reflected heat from the ship, and always at the same elevation. Such observations are best made out of sight of land, in a variety of latitudes, and at different hours of the day, and every pains taken to render them all strictly similar and comparative.

5. The meteorological instruments (if standard instruments have not been supplied) should be previously compared with each other throughout a large extent of their scales, and these comparisons tabulated for the purpose of applying the requisite corrections; and they should also be compared with the standard instruments at the Royal Observatory at Greenwich or at Kew, or at any of the home ports, both before sailing and on the return home of the vessel.

6. Any observations which involve the comparison of minute differences should be the mean result of at least three readings, and should be as much as possible the province of the same individual observer.

7. In some of those singularly heavy showers which occur in crossing the equator, and also at the changes of the monsoons, an attempt should be made to measure the quantity of rain that falls in a given time. A very rude instrument, if properly placed, will partly answer that purpose; such as a wide superficial painted tub to receive

the rain and to deliver it freely into a pipe, the diameter of which bearing a certain proportion to the aperture of the tub, will show on an exaggerated scale, the number of inches, and tenths, that have fallen.*

8. Any very brilliant displays of that beautiful phenomenon the Aurora, in either northern or southern regions, should be minutely recorded, along with the altitude of the point of coruscation, or the name of the star near which it occurs, the colour, the compass bearing of the principal luminous arch, &c., and the exact times of all these appearances, in order that they may be compared with the observations of others.

9. It has been asserted that lunar and solar halos are often so disturbed by refraction as to be more or less elliptic, and a general order might therefore be given to the officer of the watch, to measure their vertical and horizontal diameters whenever they occur, day or night.

WIND and WEATHER.—The above remarks respecting the Abstract Log apply equally to wind and weather, and any attempts to record observations under these heads will, most probably, be far behind the requirements of the present day, if the Introduction to that work be not consulted. In addition to the force and direction of the wind, the direction of the swell should be recorded when it differs from that of the wind, as well as the course of lofty strata of clouds which often move obliquely to the wind that prevails below, and as often in direct opposition to it. This information is obviously necessary to any attempt to analyse the distribution and courses of the winds, and is easily obtained at night by the passage of those clouds across the moon or stars, or in the day-time across the sun; and for the latter purpose there ought to be a few pieces of coloured glass kept in the binnacle.

TRADE WINDS and MONSOONS.—The annual periods and geographic limits of the trade winds, monsoons, and rains, and the times and local peculiarities of the daily sea and land breezes, will no doubt be subjects of constant study and observation to a zealous surveyor; for though local observations can give only local results, yet still a profusion of facts will be collected, and much genuine information secured for future combination. Hitherto, until the publication of Maury's Wind Charts and the re-publication of them by Rear Admiral FitzRoy in an improved form, now supplied to all H.M. ships, the practical seaman has not known where to seek for concise and authentic accounts of their periods, durations, and changes, a knowledge which is so essential to the due performance of every voyage; but further observations are required and especially on the hurricanes or revolving storms of the Atlantic and Indian Oceans and the typhoons of the China Seas.

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* A low-priced but serviceable rain gauge is made by Negretti and Zambra, Opticians, Regent Street, London, which, with proper attention to placing it well, would give good results even on board a ship.

NOMENCLATURE.—Distinct names to points, islands, shoals, and rocks are absolutely necessary in a chart in order to render either the log-book, the narrative, or the sailing directions intelligible; and the surveyor should therefore take great pains not only to learn their acknowledged names, but to give their correct orthography. If such cannot be obtained, then let him freely give as many new names as will answer the above purposes, but he should avoid the silly repetition of popular names, which so much tends to confuse our gazetteers and to perplex our memories. He should beware of meddling with names already established;—those which have been stamped upon such places by the first discoverer should be held sacred by the common consent of all nations, and when new ones must be given it would show better taste to make the name convey some idea of the form or character or productions of the place, or some characteristic of its inhabitants, or, still better, to adopt the native name, if pronounceable, than to exhaust the catalogue of public characters and private friends. The officers and crews have a better claim to such a distinction, which, slight as it is, helps to excite additional interest in a laborious exploring voyage.

ORTHOGRAPHY.—In writing Arabic, Indian, Chinese, Japanese, Malay, Polynesian, and African names of places in the Roman character, it should be an invariable rule to use the English consonants (*g* being hard as in *get*, and substituting *k* for *c*) and the sound of the vowels, as heard in Italian, Spanish, German, and other European languages, (which sounds are also English,) as *a* and *i* in ravine, *e* in there, *o* in mote, *u* in flute, *ai* for the sound of i, as in fine, *ei* as in they, *au* for ow, *kh* for the Arabic guttural, as in Khan, Ladakh, &c. The variety in spelling that now disfigures even some of our best published maps and charts is far from creditable.

An acute accent should always mark the emphatic syllable as Paláwan not Palăwan, Anápah not Anăpah, Galápăgos not Galapágos, Tonga·tábu not Tonga-tăbu; otherwise accents, generally, should not be used.

DAILY PROJECTION of the DATA.—It should be an inflexible law that no evening should elapse without roughly projecting all the data which have been obtained in the course of the day. This practice is not only of use in detecting omissions, and in more clearly exhibiting the line of operation to be pursued the following day, but where there is to be an extensive area to be filled with soundings it is absolutely necessary, as the best field-book that can be kept in a boat can never represent in due proportion the intervals between the lines which have been traversed, and from thence arises the unsightly crowd of figures in some places, and the negligent blanks which too often occur in others.

ORDER-BOOK.—The surveying order-book should contain not only a general statement of the work laid out for the ensuing day, but especially a rough diagram of the intended sounding operations, so that each officer, having copied it, would perceive any failure of a neighbouring party occasioned by wind or tide, and would thus be able by a slight overstretch of his own limits to redeem the defect. Those going farther off too, might on their return drop their leads and fill up gaps left by the nearer boats and thus perhaps save the dispatching another boat to finish off the work.

SIZE of the DRAWINGS.—There is too general a disposition in inexperienced surveyors to make their drawings on a very large surface composed of many united sheets of double-elephant paper, forgetting that the changes from dry to damp weather, or even from morning to afternoon, will act unequally on different parts of the paper, and will thus distort all their straight lines, and render nugatory all their most delicate accuracy, forgetting also how thoroughly their neat workmanship will be crumpled and destroyed by the necessity of doubling and redoubling those huge sheets when copying for the engraver. It is a wiser plan to project a skeleton of the whole work with all its crossing angles and bearings on a small scale, and then to compute the sides of the secondary triangles included in the great chain, so as to transfer successive portions to separate sheets of moderate size on which they can themselves work with convenience and freedom, and from which others can work without doing damage. The paper used should invariably be mounted on linen.

SCALES of the CHARTS.—The leading rule with regard to the scales of the charts and plans in every survey should be, that they distinctly show all those minutiæ of the coast which may be required to be known not only for the purposes of navigation, cruizing, and landing, but also for reference hereafter by courts-martial or other authorities in cases of wreck, &c., when the original drafts of the survey become deposited documents in the Admiralty. The scales on which it may afterwards be expedient to publish them for the benefit of the seaman or the geographer depend on a variety of circumstances, of which the surveyor while carrying on the survey will, most probably, be enabled to form a good opinion, which he should not fail to communicate to the Hydrographer for his guidance.

No specific scales therefore can be here assigned for the projection of all surveys: each case must be determined by the character of the coast. If straight, steep, bold, and forbidding, or if it be the sandy edge of an extensive desert where no inhabitants can probably exist, and where an unceasing surf denies all access to it by boats, a scale of one inch to a mile or less will be sufficient; but where prominent headlands and receding bays show that shelter may be obtained, or where varying soundings stretch off to a considerable distance, or where from a teeming population it is evident that some intercourse must take place with the sea, then the scale should not be less than two or more inches to the mile; and in plans of ports, roadsteads, or rivers, where numerous rocks, banks, and other intricacies occur, a proportionably larger scale should be employed, reaching to 6, 12, 18, 24, or even 60 inches to a mile.

MODE of WRITING the NAMES.—In adding the names, much advantage will be derived from placing them systematically; the clearness and utility of a chart is greatly enhanced by the writing being well arranged. The natural and obvious rule would be for all writing to be horizontal; and when the coast or the general features run nearly north and south, that rule may be agreeably followed, but, with oblique or winding, or east and west coasts, such writing often appears confused, and its application uncertain. A middle course should, therefore, be adopted on a coast which faces the north or south. Another little nicety is worth attention: the names should commence nearly at right angles to the coast, and then curve round to the right or left according to the trend of the shore. Different characters, such as capitals, print, italics, &c., should be used according to the importance of the place. Text might be applied to ancient names. Abbreviations in certain cases may be admissible, but the seaman should seldom be left to guess at the meaning of initials.

It may be thought that too much has been said on this branch of the subject, as applying more to the appearance and beauty of the chart than to its acccurate construction and practical utility; but everything that ought to be expressed should be so placed as to prevent any ambiguity, and especially in charts intended for the use of the seaman, who sometimes requires instant information, and therefore all should be so written as to catch his eye without consideration or study. All should be clear, distinct, and obvious; the names or remarks near each other should have the same general direction instead of obliging him to turn the chart in different ways in order to read the neighbouring words; they should be so placed as not to confuse the soundings or interfere with the channels, marks, or bearings; and generally words spread out over a large space, with the letters limping at long intervals after each other, are perplexing.

VIEWS.—Good charts and plans should be accompanied by views; those which are to be attached to charts of a coast should be taken at such a distance as will enable a stranger to recognize the land, or to steer for a certain point; while those suited to the plan of a port should show the marks, either for avoiding dangers, or for shaping the course to the entrance, or for taking an advantageous berth; bearings by compass of the principal points should always be added. In these views, the horizontal angles of the leading points, and the angular altitudes of the principal objects, should be inserted in degrees and minutes, by which means they can be corrected by scale, so as to obviate any want of precision in the eye of the draftsman. The names of points in the back ground should be given at the bottom of the views with a reference. Such views cannot be too numerous; they will well repay the time bestowed on them, are a great resource in any case of doubt, and when selected with judgment are extremely valuable to the navigator.*

HILL DRAWING.—In representing mountains and hills, which in general cost so much labour, and are too often put in from fancy or from memory after the lapse of time, the surveyors are recommended to employ very open strokes of the pen, as being better adapted to denote the extent and direction of the several slopes than the brush alone, and if not worked up to make a picture, will cost as little or less time, provided the altitudes are expressed in figures; or they may be represented by contour lines when an opportunity offers for measuring them which can often be readily done by means of the aneroid barometer. The in-shore sides of the hills, which cannot be seen from any of the stations, must be mere guess-work, and therefore are better all omitted.

TITLE.—The title should be bold and simple. It should give the names of all the surveyors and assistants employed on the work and in making the views. In a harbour plan the latitude and longitude of observation spot or of some chief place should be given; also the tides, the variation, and to state whether the soundings are in fathoms or feet. A true meridian line should invariably be ruled out across the drawing of every plan; the scale should be inserted, and two or three magnetic compasses should be drawn in suitable places in both charts and plans.

TRACINGS.—Tracings of each sheet of the survey, when completed, should be always kept ready for any opportunity that may occur for transmitting them to the Admiralty, which should invariably be done at the earliest occasion, not only that they may be speedily published for the benefit of the mariner, but also, in the event of wreck, that the work may not be lost.

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* In views of distant low land, it is usual to exaggerate the vertical height one-third, but whenever done it should always be carefully noted.

NATURAL HISTORY.—No opportunity should be missed of making collections in Natural History consistently with the more immediate duties of the survey. It is probable that the medical officer of the ship will have some knowledge of this subject, and he should be encouraged to collect specimens, have the assistance of a boat when needed, and space to keep his collections. The Geology of a country should be studied by all, were it only for the due representation of the natural features on the chart, as mountains of granite, slate, or limestone usually assume different forms: inquiries, too, for minerals and especially for coal, should never be omitted. In Botany the more important point would be timber for ship building and masts, but hardy evergreens suited to our climate, and trees producing resins, gums, and plants with medicinal properties, &c., would be of value to commerce. In Zoology new or rare forms of animal life, insects, &c., and especially submarine researches are likely to be productive of much novelty; the dredge frequently put overboard will generally bring up something worth keeping. In Ethnography glossaries of little known native languages, well selected crania of the aboriginal natives of Malacca, Borneo, Celebes, and the Asiatic Archipelago generally, would be greatly prized in our museums. On all these subjects very full instructions for collecting and preserving will be found in the Admiralty Manual of Scientific Enquiry already frequently referred to.

SAILING DIRECTIONS.—Nautical descriptions of the places comprised within the limits of the survey, the aspect of the coast on making the land, and clear directions for the ports and dangers, adapted to all classes of seamen, and especially for recognizing the land by day, at night, or in thick weather, are to be considered as one of the most essential parts of every survey. But much miscellaneous information should be likewise inserted, such as an account of places of refuge after any disaster at sea; the means of repairs, as the number and dimensions of graving docks, floating lift docks, patent slips, &c.; the mode of obtaining pilots when required, the best method of getting water, wood, coal, and other supplies, the price of refreshments, the general resources and productions on which vessels may depend; the defences of the place; and means of communication by roads, railroads, or electric telegraph. In high northern or southern ports whether they freeze over, and if so when does the ice form. Commercial statistics, as the number and tonnage of the arrivals and sailings, and of ships belonging to the port, the chief exports and imports and their value, and the population of the place; also the means for rating chronometers by time signal or otherwise; the usual effects of the climate in the rainy and in the dry seasons, and notices of those spots which are peculiarly unhealthy; in short, all facts that can be useful to the sailor or the merchant.

In Sailing Directions for foreign coasts a glossary of the native names of the more common topographical terms, as cape, hill, island, river, &c., should be given; also a table of money, weights, and measures, with the points of the compass, in the native language.

Courses and bearings are invariably to be given by compass. If for some special reason the true bearing is required, it may be added; as the bearing of two light towers or two beacons, which, seen in one, would enable a ship to ascertain the local deviation of her compass in passing. In compiling sailing directions we must never forget that we are writing not only for educated officers but for sailors, for the immediate practical use of the pilot or seaman, many of whom know little of true bearings. As the variation at a certain date, and its annual change, should be given at the beginning or end of each chapter of the work and on every chart, those who require true bearings can easily obtain them.

In his inquiries on all the above subjects the surveyor will derive great assistance from the many excellent papers in the Admiralty Manual of Scientific Enquiry, the constant study of which cannot be too strongly recommended, as well as in Special Instructions on those points published by the Hydrographic Office.

SURVEYING JOURNAL.—Lastly, a constant register, in a book solely devoted to that purpose, should be daily and faithfully kept of the whole process and progress of the survey, showing the methods that have been adopted, the general results of the large triangulation, the points on which it was based, and the measurement by which it was confirmed, and faithfully stating the corrections which from time to time have been introduced from auxiliary chains of triangles, from chronometric differences of longitude, or from astronomical observations. This journal, together with the field books, the original observation books, the reduction books, the tide registers, and the entire series of rough charts or first projections,—all these documents having been distinctly endorsed and dated,—are at the conclusion of the survey to be deposited in the Hydrographic Office of the Admiralty.

I. W.

Hydrographic Office, Admiralty, London.
1 *January* 1862.